bars, the spots rounder on the breast, and squarer and larger on the flanks; thighs tawny, mottled with chocolate-brown centres to the feathers; under tail-coverts pale tawny buff, mottled like the breast with brown bars and large rounded white spots; under wing-coverts dark chocolate-brown, the inner ones and axillaries pale rufous on their edges; greater under wing-coverts blackish below, with broad bars of white on the inner web; quills blackish below, with obsolete paler bars on the inner web, rather plainer near the base, the first primary hoary white near the base of the outer web, and notched with hoary white for the greater part of the latter. Total length 12 inches, culmen 0·75, wing 8·7, tail 5·0, tarsus 1·25.

Fam. Paradisiidæ.

Genus Amblyornis.

Amblyornis subalaris, sp. n.

Differs from *A. inornatus* in being more dingy in colour below, being dusky brown, with fulvous centres and narrow fulvous shaft-lines; under wing-coverts and inner lining of quills rich ferruginous, instead of orange-buff. Total length 8 inches, culmen 0·9, wing 4·65, tail 3·4, tarsus 1·4.

On the Anatomy and Functions of the Tongue of the Honey-Bee (Worker). By Travers James Briant. (Communicated by B. Daydon Jackson, Sec.L.S.)

[Read 3rd April, 1884.]

(Plates XVIII. & XIX.)

In order to arrive at a just appreciation of the relationship of the tongue of the Bee to the rest of the head, it will be necessary to refer to the more conspicuous parts of the endo-skeleton to which it is related.

From the lower half of the ring which surrounds the occipital foramen arise two pillars (*a*, fig. 1, longitudinal section of head, without muscles; fig. 2, horizontal section, with muscles), which pass obliquely downwards to the front wall of the head, and there

blend with two ridges that correspond inwardly with the furrows, which, on the outer surface, mark off the clypeus. From the lower side of the base of each of these pillars spring second pillars (*b*, figs. 1 & 2), running parallel with those first mentioned until they approach the outer wall of the head, where they terminate in a bifurcation; they cannot, however, in strictness be considered pillars, as they each unite with and form part of the chitinous wall bounding the oral chamber.

This bifurcation receives the end of the cardo (*d*, figs. 1, 2, & 5, details of the base of maxilla, with adjacent parts). The cardo is channelled on the medial side and terminates at each end in two unequal processes, those at the forward end receiving the muscle *ex m*, those at the other being hinged to the base of the maxilla (see fig. 5); in the centre of this fork is placed the end of one of the wings of the lora (*e*, fig. 3, longitudinal section of head, with muscles; figs. 5 & 6, tongue of queen from above). The central portion or body of the lora is triangular in shape and is hinged to the base of the mentum.

The mentum is a semitubular body, bearing at its anterior end the labial palpi, the tongue, and the other organs connected with it. It contains the muscles acting directly on the tongue, and the salivary valve; and into it is withdrawn a large portion of the basal end of the tongue in the manner hereafter to be described. The anterior end (fig. 15, from above) is cut by two longitudinal notches; the central portion bears the paraglossæ, the hyaline rod which traverses the tongue (*l*); and the lateral parts bear the palpi. These latter organs (fig. 7) consist of one long and three succeeding shorter joints. The long joint contains a muscle which acts upon the remaining joints. The whole organ is kept in its place adpressed to the tongue by a muscle which arises from the walls of the mentum (*p*).

The maxilla (fig. 9) consists of a stipe and a blade. When the maxillæ are closed together, they cover the tongue on the upper or forward side, and, together with the labial palpi, completely surround it. When folded back the blades carry with them the tongue and palpi; the lower edge of the blade fits into the space between the base of the maxilla and the mentum, and thus the whole apparatus is neatly tucked away and safely protected. The lower side of the blade is plaited at its anterior end (fig. 14), the extreme edge is fringed with hairs (*d*), and between these hairs are smaller

hairs or bristles (*b* and *c*) seated on papillæ; alternately a shorter and weaker hair on a longer papilla and a longer and stouter hair on a shorter papilla. There is nothing in the appearance of the end to support the assertion frequently made, that it is used for cutting purposes. The harder the chitine, the darker it is; but the end of the blade is very transparent and delicate.

The movements of the organs before mentioned are controlled by the following muscles. A pair of muscles (*ex m*^{1}, figs. 2 & 5) which spring from the outer base of the cranial pillar (*a*) are inserted into the end of the cardo (*d*), together with a second pair, which spring from the back wall of the head, *ex m*^{2}. The contraction of these moves the cardo on the fulcrum formed at its juncture with the walls of the oral chamber, and consequently carries forward the lower end and the parts attached thereto; that is, the whole mentum and the maxillæ. The posterior end of the maxilla is brought forward by the muscle *mx*^{1} (fig. 4, lower portion of longitudinal section of head, showing muscle; and fig. 5), and this muscle is opposed by the muscles *mx*^{2} and *mx*^{3}. The lateral movements of the maxilla are produced by the action of a muscle found in its base (*mx*^{4}, fig. 5), which is inserted into the end of a dark chitinous strap (*j*, figs. 4, 5, & 6). This strap is hinged at one end to the side of the inner oral chamber at *h* (figs. 5 & 6). The contraction of *mx*^{4} results therefore in drawing aside the whole organ, the elasticity of the hinge being sufficient to restore it again. The blade of the maxilla is extended by the muscle *mx*^{5} and flexed by *mx*^{6} (fig. 5).

The general appearance of the tongue is that of a slightly tapering brush-like organ densely covered with long hairs, which, when extended, is longer than the palpi. Within this, however, is a hyaline rod, which, arising from the central part of the end of the mentum (*l*, fig. 15, also fig. 8, longitudinal section of mentum, with tongue extended; fig. 9, the same, with tongue contracted; and fig. 10, section of tongue, A, taken near the root B, taken about halfway down). This rod terminates in a bifurcation upon a small ladle-shaped organ at the extremity of the tongue (*l*, A and D, fig. 11). The outer wall of the tongue is attached to it directly only at the anterior end. In section it will be seen that the side of the rod turned towards the bee is channelled by a groove which runs through its entire length. The outer wall of the tongue is not tubular, but is open along the back; the edges of this slit are united to

each side of the rod by means of very thin expansions of membrane (*m*, fig. 10), one side of which is covered by hairs; the hairs at the anterior end are very short and are seated on irregular papillæ (fig. 18), whilst those at the posterior end arise from regular pointed papillæ and are somewhat longer (fig. 16, from above, fig. 17, from the side). The existence of this membrane may be easily demonstrated if the entire head of a recently killed bee with the tongue extended be placed in an ordinary live-box and be subjected to pressure. The rod, which is naturally curved, being pressed in the middle and being supported at both ends, is forced out of its place, and brings with it the membrane in question. Professor A. J. Cook, of Michigan, appears to think that the bee when feeding brings the rod to the outside and so increases the internal dimensions of the tongue by adding that of the second chamber formed by the membrane; and this opinion is shared by Mr. J. Spalding (Amer. Nat. Feb. 1881, p. 113), both authors giving illustrations in explanation. After many observations of bees when feeding, some made with the microscope, I cannot agree with this view; certainly it is not their invariable way of feeding, and, in fact, I have never seen any bee feed in this way.

The hairs covering the surface of the tongue are long and finely pointed, with flattened bases, and are arranged in regular whorls (fig. 15). The hairs near the base of the tongue are much shorter and broader, and are sometimes split into two or three points. Interspersed among these hairs are a number of bristles which occur on every fifth whorl. These bristles are similar in character with those found on the edge of the maxillæ, on the end joints of the palpi, and on the extremity of the tubular portion of the tongue itself. They all follow one type, viz. that of a bristle arising from the summit of a papilla. I am inclined to consider that they are touch-organs, and nothing more. It must be borne in mind that, covered with a hard skin, as all insects are, their nerves can hardly be susceptible to external influences to any great extent. These soft parts in their harness supply this deficiency. Then, it may be urged, why not consider those on the tongue as organs of taste? The answer is, that on two occasions, when desirous of making bees feed on coloured honey (one bee being under chloroform, and the other torpid through cold), no motion was produced in the tongue when honey was brought in contact with it. I do not presume to say the bee did not taste it, but it made no outward and visible sign that

it did. Immediately, however, I moved the honey and touched the antennæ of these same bees with the same honey, the usual movements of the tongue were produced, although there was then no honey touching the tongue. I cannot therefore suppose that these bristles in the region of and on the tongue are taste-organs.

On the outer surface of the base of the tongue is a smooth groove (*n*, figs. 8 & 24, base of tongue, from above); this is only found in the workers. When bees feed one another, the tongue of the bee that is taking the food is applied to this groove on the tongue of that which is supplying it. The importance of it being free from hair is clear when it is remembered that an extension and contraction of the tongue is, except in one condition, the invariable mode in which the bee obtains its food; it would obviously be impossible for the tongue, thickly covered with hairs as it is, to pass over another surface as thickly covered, more especially when the hairs are in each case directly opposed to one another.

The posterior end of this feeding-groove is hinged to a lever (*o*, figs. 6, 8, & 9), the shape and position of which can best be understood from a reference to the figure. From the centre of the lower part of this lever arise two chitinous processes—one dark, curving forward, and uniting with the paraglossæ (*p*, fig. 8); the other hyaline, which, passing upwards, forms one side of the lower part of the salivary valve (*q*, fig. 8). To the lower end of the lever is affixed the muscle T; the contraction of this muscle will act upon the lower chitinous process running to the salivary valve, and serve to close it. The salivary valve just referred to is semicircular in transverse section (*t*, fig. 23); and, when viewed from above, is irregularly oblong (*t*, fig. 22). A pair of muscles (s^1, figs. 8 & 9) act upon it from below, and two other pairs (s^2 and s^3, figs. 6, 8, & 9). At the posterior end it receives the salivary duct (*r*, figs. 3, 6, 8, & 9). This duct arises in the thorax, and, after there collecting the saliva, receives the products of the glands, found on each side of the head, and then passes into the mentum.

The tongue and paraglossæ, but not the palpi, are partially withdrawn into the mentum, in the manner shown in fig. 9, by the action of a pair of muscles (*r.t.* figs. 2, 3, 4, 6, 7, 8, & 9); they arise from the upper and hinder part of the head, and are inserted at the upper part of the paraglossæ.

In that part of the mentum surrounding the salivary valve is the chamber in which the syrup or nectar comes in contact with

the saliva, and from which it passes upwards to the pharynx. This chamber is almost obliterated when the tongue is retracted and drawn within the mentum; while, on the other hand, on the protrusion of the tongue its capacity is considerably increased. This can be more readily understood by reference to the diagrams figs. 25 and 26, the asterisk (*) being the chamber.

Before considering the action of the tongue, a reference must be made to the ladle-shaped organ found at the tip of the tongue (fig. 12, from above, fig. 13, end on, and fig. 14, side view). Mr. Hyatt describes and figures it as a hollow cone or funnel which serves as a sucking-disk (Amer. Q. Mic. Journal, 1879, vol. i. p. 287). Others have spoken of and regarded it as a button. Upon the concave surface of this ladle-shaped organ are a number of curious hairs, shown at fig. 15; they are branched and divided in the manner shown, with the hairs turned inwards.

The true nature and function of the tongue has been the subject of discussion from very early times. Mr. Chambers, in the 'Journal of the Cincinnati Society of Natural History' (April 1878), summarizes the various views entertained at different times. It will be necessary briefly to refer to some of these theories. Kirby and Spence (Introd. vol. ii. p. 177) say the tongue, "though so long and sometimes so inflated, is not a tube through which honey passes, nor a pump acting by suction, but a real tongue, which laps or licks the honey and passes it down on its upper surface, as we do, to the mouth." Huxley follows this, and says, "Functionally this organ is a tongue, and enables the bee to lap up the honey on which it feeds." Newport goes more into detail, and says:—"It is not tubular, but solid ... the manner in which the honey is obtained when the organ is plunged into it at the bottom of a flower is by lapping, or a constant succession of short and quick extensions and contractions of the organ, which occasions the fluid to be accumulated upon it and ascend along its upper surface until it reaches the orifice of the tube formed by the approximation of the maxillæ above and the labial palpi and this part of the ligula below... At each contraction a part of the extended ligula is drawn within the orifice of the tube, and the honey with which it is covered ascends into the cavity of the mouth, assisted in its removal from the surface of the ligula by the little bunch of hairs with which the elongated second joint of each labial palpus is furnished." I have quoted this at length, as it is substantially the same as that given by Hermann Müller in 'Nature,' vol. viii. p. 189.

If a bee be put to a large drop of honey, it will be found to open slightly the whole of the organs of the tongue, and with a scarcely perceptible motion suck in honey, no doubt by means of, or largely assisted by, the muscular pharynx (*s*, figs. 3 & 4). Flowers, however, do not ordinarily contain nectar in such abundance nor in such convenient positions. The nectaries are described as usually only a small spot, which, without becoming more prominent, produces the nectar; but frequently they are in the form of a glandular protuberance, or project in the form of cushions, or, again, as shallow excavations (Sachs' 'Text-book,' 2nd ed. 1882, pp. 494–569).

In order to obtain the conditions more nearly approaching those in nature therefore, the honey should be presented smeared thinly on a bit of glass. If this be done, the bees will clear off every trace of honey, and leave the glass as clean as it was before the honey was smeared on it. This is done by the bee applying the lower and outer portion of the tongue to the surface of the glass, in the manner shown in diagram, figs. 25 & 26. The long joints of the labial palpi just touch the glass, the shorter joints being bent outwards at right angles. The tongue is then extended and retracted with great regularity and some speed, and to me it appears that the extension is a somewhat slower movement than the retraction. When the tongue is in this position the "ladle" will be turned with its concave side downwards, and that surface of the tongue which is split will be upwards. The pressure on the surface of the glass will move the rod to the opposite side of the tubular portion of the tongue in that part of it which is being pressed against the glass. This will cause the two membranes (*m*) to form a trough, which will of course be opened on its upper surface; and, although I have not actually observed the fact, it seems impossible to suppose that the honey does not pass into this trough. As the tongue is being retracted, the rod which was pressed against the inner side of the tongue will pass over to the front side, and so considerably enlarge the trough made by the membranes in the upper portion of the tongue, and the edges of the slit in the outer wall being closely united by interlocking hairs, the result will be the creation of a vacuum which will draw up the honey from the lower portion of the tongue. The tongue is then again extended; but now the salivary chamber is enlarging as the tongue is protruded, and the honey is so carried up still higher and into the mouth, whence it is once more drawn up by the muscular pharynx.

This, however, will not account for the bee being able to remove such minute traces of honey as it undoubtedly can. The hairs of the tongue will sweep backward the honey, that is to say, will drive it away from the mouth, towards the end of the tongue itself, and the ladle-shaped organ will then serve, as the tongue is being withdrawn, to collect and drive into the tongue the honey thus collected. When within the tongue, the capillarity of the narrow groove, assisted by the action of the salivary chamber, will afford a means, which the larger opening would not afford, of the smallest particle of honey being sucked up.

Professor Cook, in a paper reported in the Amer. Bee Journal, Nov. 1879, gives the following account of some experiments which support this view. He says:—"I have placed honey in fine tubes and behind fine wire gauze, so that bees could just reach it with the funnel [the ladle-shaped organ] at the end of the rod. So long as they could reach it with the funnel, so long would it disappear. I have in such cases seen the red axis when the bee was sipping coloured syrup. Subsequent examination by dissection revealed the red liquid still in the tube of the rod."

Bees always apply the forward and lower side of the tongue to the honey, even when it is put into a position in which almost any other way would appear more convenient.

The statement which has found its way into so many books that bees obtain the honey by lapping*, appears to me to be without foundation. The length and direction of the hairs, *i. e.* all pointing away from the bee, is sufficient to condemn it.

The next theory,—that propounded by Hermann Müller,—is as follows:—"The terminal whorls of hairs are filled with honey by adhesion; this honey is withdrawn into the sheath of the tongue [formed by the meeting of the maxillæ and the palpi], and is driven towards the œsophagus by a double cause: first by the pressure of the erect whorls of hairs, and secondly by suction." He elsewhere says the whorls of hairs are erected rhythmically, and that the suction here referred to is due to the action of the stomach. I cannot, however, accept this explanation, for (1) there does not appear to me to be any reason for supposing the hairs of the tongue are capable of being voluntarily erected; (2) the tapering shape of the tongue and the direction and length

* "Functionally this organ is a tongue and enables the bee to lap up the honey on which it feeds" (Huxley's 'Manual of Invertebrata' p. 428). See also John Hunter, in Enc. Brit. 1875, "Bees;" Shuckard, 'British Bees,' 1866, p. 37 *et seq.*

of the hair seem opposed to the idea that its withdrawal in the tubular surroundings would drive the honey towards the head; (3) the dense covering of hair seems to make such a mode of action impossible; (4) it does not account for the organs inside the tongue nor for the ladle-shaped appendage before referred to.

Shuckard, in his 'British Bees' (p. 37), although he holds to the lapping theory, says that if a bee be observed whilst sipping any sweet liquid, the anterior portion of the tongue will be sometimes seen more swollen than when [? not] in action, and alterations will be observed in it of varying expansions. At another place he says the bee is also seen to curve the tongue about, causing from time to time the superior surface to become concave, to give, as it were, to the liquid with which it is loaded a downward inclination towards the head. The extremity is frequently above the surface of the liquid, and again the tongue can swell and contract; "these swellings and constrictions are observed to succeed each other."

These observations seem to me to support the theory I have here ventured to propound, namely, that the honey is drawn into the mouth through the inside of the tongue by means of a complicated pumping action of the tongue itself and its closely contiguous parts, and not in any sense by lapping.

DESCRIPTION OF THE PLATES.

Plate XVIII.

Fig. 1. Longitudinal section through head of Bee, without muscles. *a*, Chitinous pillar supporting the front of the head; *b*, second pillar, from the side of which arises the thin chitinous wall *c*; *d*, cardo; *f*, base of maxilla.

2. Transverse section through same. *a*, *b*, and *d* as before; *Ex m* and *Ex* m^2, muscles inserted into the head of cardo; *rt*, retractor of tongue.

3. Longitudinal section through head, with muscles. *h*, Thin wall of the upper side of mouth-cavity; *r*, salivary duct; *rt* as in fig. 2; *s*, pharynx; *g*, mentum; *e*, lora.

4. Longitudinal section through anterior end of head, with muscles. *a*, Portion of chitinous pillar as in fig. 1; *h*, *s*, and *rt* as in fig. 3; *j*, chitinous strap divaricating the maxillæ; *f*, base of maxilla; mx^1, mx^2, and mx^3 respectively, muscles of the maxilla.

5. Enlarged figure of the base of maxilla and adjacent parts. *d*, Cardo; *e*, lora; *f*, basal joint; *g*, mentum; *h* as in fig. 3; *j* as in fig. 4; mx^1, mx^2, mx^3, ends of muscles mx^1, mx^2, and mx^3 of fig. 4; mx^4, muscle lying behind *j*, which draws the maxilla outwards: mx^5, extensor of blade of maxilla, mx^6; mx^7.

6. Tongue of Queen Bee and adjacent parts, from above. *d*, Section through cardo; *e*, *f*, *g*, *j*, as before; *h*, section through thin wall of mouth-cavity, as in figs. 3 and 4; *o*, lever at root of tongue from above; *r*, salivary gland; *rt*, retractor of tongue; s^2, muscles inserted into sides of the outer wall of salivary valve; s^3, muscles inserted into the centre of same.

Fig. 7. Palpus, with portion of mentum, *q*, attached. *h*, Wall of mouth-cavity, as before; *k*, forward side of paraglossum; *p*, muscle inserted into paraglossum, and withdrawing same; *rt*. as before.

PLATE XIX.

8. Section through base of tongue and mentum, extended. *g*, Mentum; *e*, lora; *l*, hyaline rod of tongue; *n*, feeding groove; *t*, salivary valve; *o*, lever of tongue, as in fig. 6, side view; *p*, paraglossum; *q*, ridge from posterior side of salivary valve, united with lever *o*; s^1, muscle acting on posterior side of valve; s^2 and s^3 as before; *to*. muscle inserted into foot of lever *o*, and throwing same forward.
9. The same, retracted.

Fig. 10. Transverse section through tongue near base. *l*, Hyaline rod; *m*, membranous bag; *n*, feeding groove.

11. The same, towards the end.
12. Ladle-like organ at end of tongue, sometimes called the "button." *l*, Hyaline rod of tongue, showing bifurcation.
13. The same, end view.
14. The same, side view.
15. Branched hairs on same.
16. Hairs on the inside of membranous bag, *m*, of figs. 10 and 11, from above, showing ridges of papillæ upon which they stand.
17. Side view of same.
18. Side view of same near the anterior end, showing irregularly shaped papillæ.
19. Hairs on surface of tongue with expanded bases. *b*, Sensory bristles scattered through same.
20. The same, from base of tongue.
21. Portion of blade of maxillæ. *aa*, Plications; *bb*, sensory bristles, the longer ones on shorter pillars; *cc*, the same, the shorter ones on longer pillars; *d*, longer hairs of same.
22. Anterior end of mentum (without muscles), showing salivary valve; *l*, Base of hyaline rod springing from chitinous tongue.
23. Transverse section of same.
24. Posterior end of tongue, showing feeding groove, *n*.
25 & 26. Diagrammatic view of tongue when feeding. *t*, valve. Fig. 25 is the position of tongue and internal parts as it arrives at the termination of the extension motion. Fig. 26, The same, at the termination of the retraction motion.

On a new Genus of Recent Fungida, Family Funginæ, Ed. & H., allied to the genus *Micrabacia*, Ed. & H.

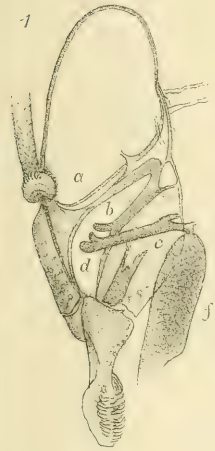
By Prof. P. MARTIN DUNCAN, F.R.S., Vice-Pres. Linnean Society.

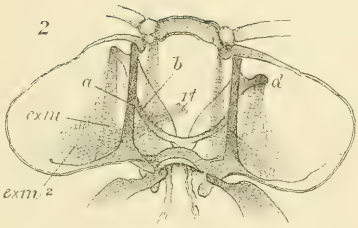
[Read 5th June, 1884.]

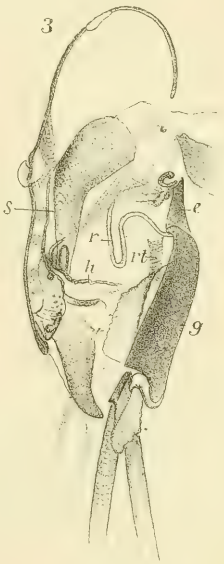
(PLATE XX.)

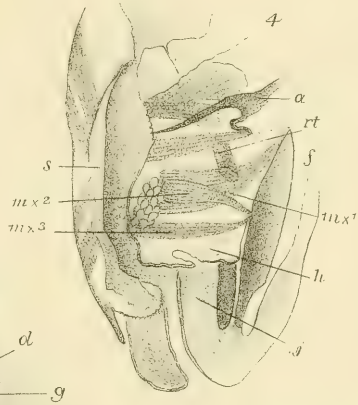
Genus DIAFUNGIA, genus nov.

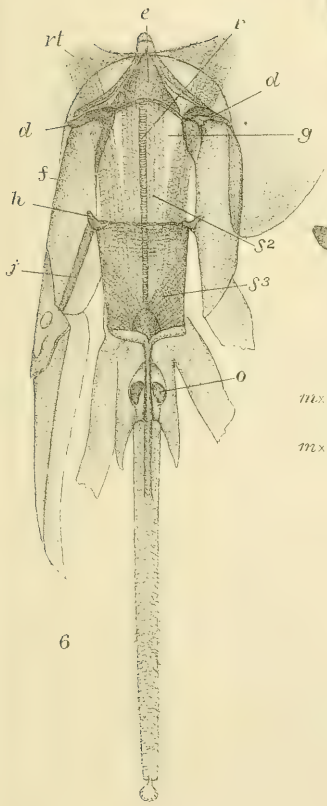
Corallum discoid, free, without trace of adhesion, not quite circular in outline, much broader than high. Base with a primary triangular piece extending beyond the centre, slightly projecting downwards, the rest of the coral grouping from its sides and apex, so that there is an appearance of former fracture and subsequent mending. Calice unsymmetrical from the prolongation of the larger septa of the primary piece beyond the

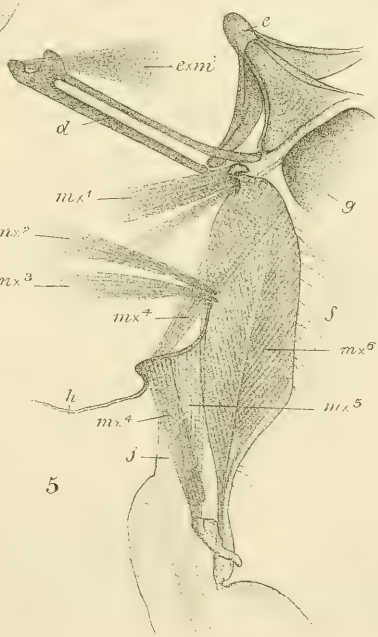






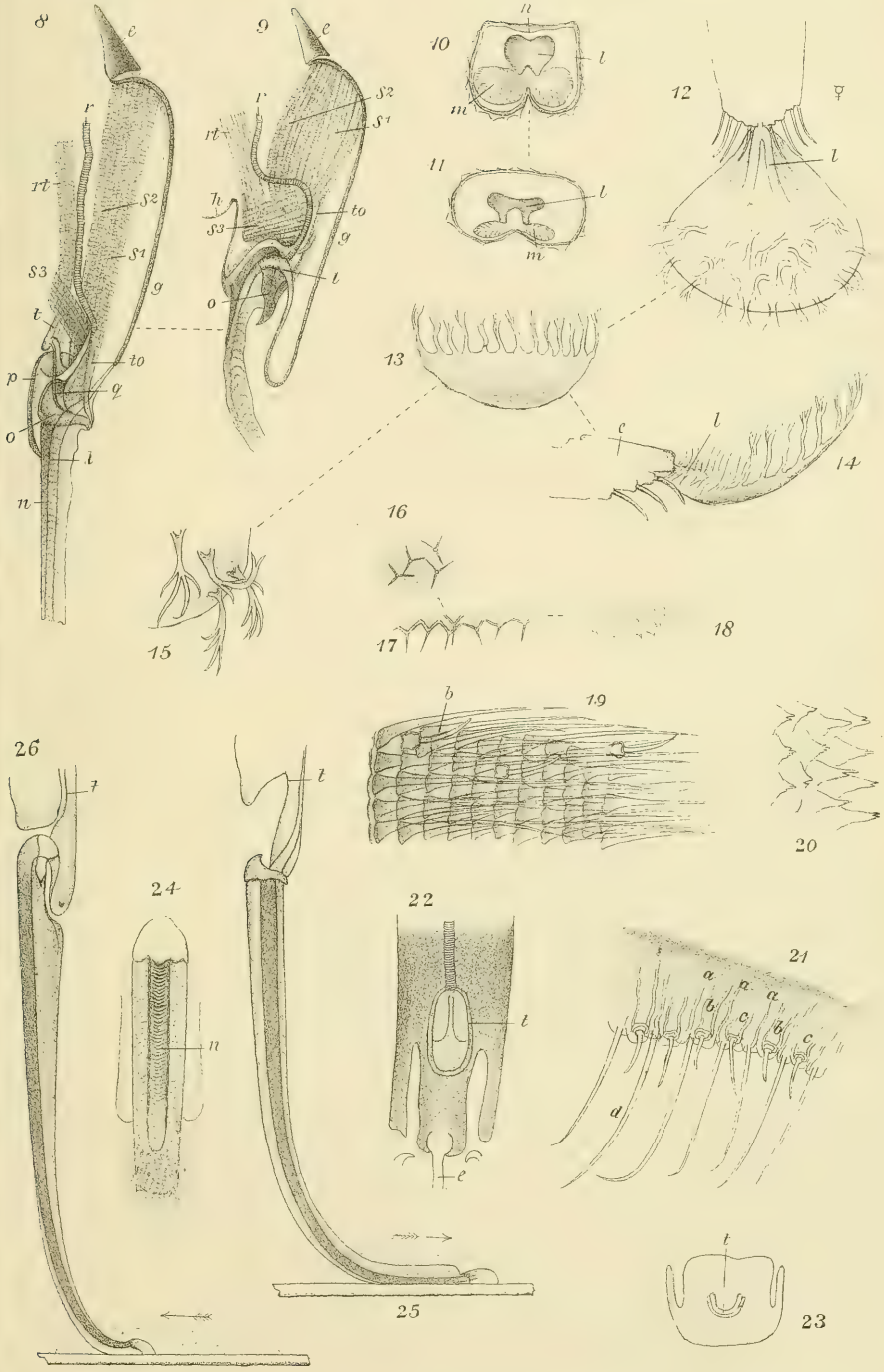






Hammond lith. Hanhart imp.

ANATOMY OF TONGUE OF HONEY BEE.



ANATOMY OF TONGUE OF HONEY BEE.